SPACE SCIENCE AND ENGINEERING CENTER

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Madison, Wisconsin 53706-1695

5 February 2002

Dr. Joe Bredekamp
Technical Officer
NASA Headquarters
Code 077.0
300 "E" Street. SW
Washington, DC 20546

Re: Grant NAG5-9483

Dear Dr. Bredekamp:

Please find enclosed the original and two copies of the final technical report for the referenced grant entitled "Collaborative Analysis and Visualization of Space Science Data Using Java and VisAD" with Drs. Wilton T. Sanders and William L. Hibbard.

If you have any concerns or questions, please call me at (608)262-0985. Thank you for your continued support and assistance.

Sincerely,

John P. Roberts
Executive Director-Administration

Enc. (3)

Cc: Winifred R. Otten, Grants
B. Hibbard
W. Sanders
ONRR
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Final Progress Report for NASA Grant NAG 5-9483

This is the Final Report for NAG5-9483, *Collaborative Analysis and Visualization of Space Science Data Using Java and VisAD*, which began 1 April 2000 and ended 31 March 2001. This effort has accomplished its proposed goals, specifically:

1. VisAD has been ported to Java.
2. VisAD supports collaborative user interfaces and distributed computation using Java RMI (Remote Method Invocation).
3. VisAD supports a very general numerical data model that integrates a variety of metadata.
4. VisAD includes interfaces to file formats commonly used by space scientists, including FITS and netCDF. Programmers funded by this effort assisted Tom McGlynn in developing his Java interface to FITS files.
5. VisAD supports a general display model that includes 2-D, 3-D, animation, interaction, immersive virtual reality, direct manipulation, collaboration and extensibility.
6. VisAD includes a general spread sheet with an infix formula interpreter.
7. The development of the "Collaborative Galaxy Designer" as an example space science application.
8. The creation of extensive on-line documentation.
9. The system, including source code, is freely available via the World Wide Web. The VisAD user community is growing rapidly.

VisAD is now a class library written in Java 2 (also known as JDK 1.2). It uses Java2D and Java3D for graphics, uses JNI (Java Native Interface) for connections to science algorithms coded in Fortran and C, and uses Java RMI (Remote Method Invocation) for distributed objects. A VisAD application consists of a network of data, display, computation and user interface objects, which may be arbitrarily distributed around the physical network. Collaborative capabilities are built in to many of the VisAD classes. For example, simply linking displays on two different workstations to the same data object can create a collaborative visualization. Similarly, linking user interface components on two different workstations to the same data object can create a collaborative control.

VisAD defines a numerical data model that can be applied to virtually any numerical data. The data model integrates data organization information, units, coordinate systems, sampling geometries and topologies, missing data indicators and error estimates. These metadata are integrated into computational and visualization operations on data, so that unit conversion, coordinate transforms and resampling are done implicitly as necessary. Missing data and error estimates are propagated in computations. These metadata are more elaborate than described in the proposal, as a result of detailed analysis during the system re-design.

The VisAD data model has been implemented for a number of file formats, including FITS netCDF, HDF-EOS, McIDAS, Vis5D, GIF and JPEG. An HDF-5 implementation is under development. Note that many of these implementations were done outside of this effort. In addition to AISRP, VisAD development is being supported by the NCSA Alliance, the Unidata Program Center, NOAA and the Australian Bureau of Meteorology.

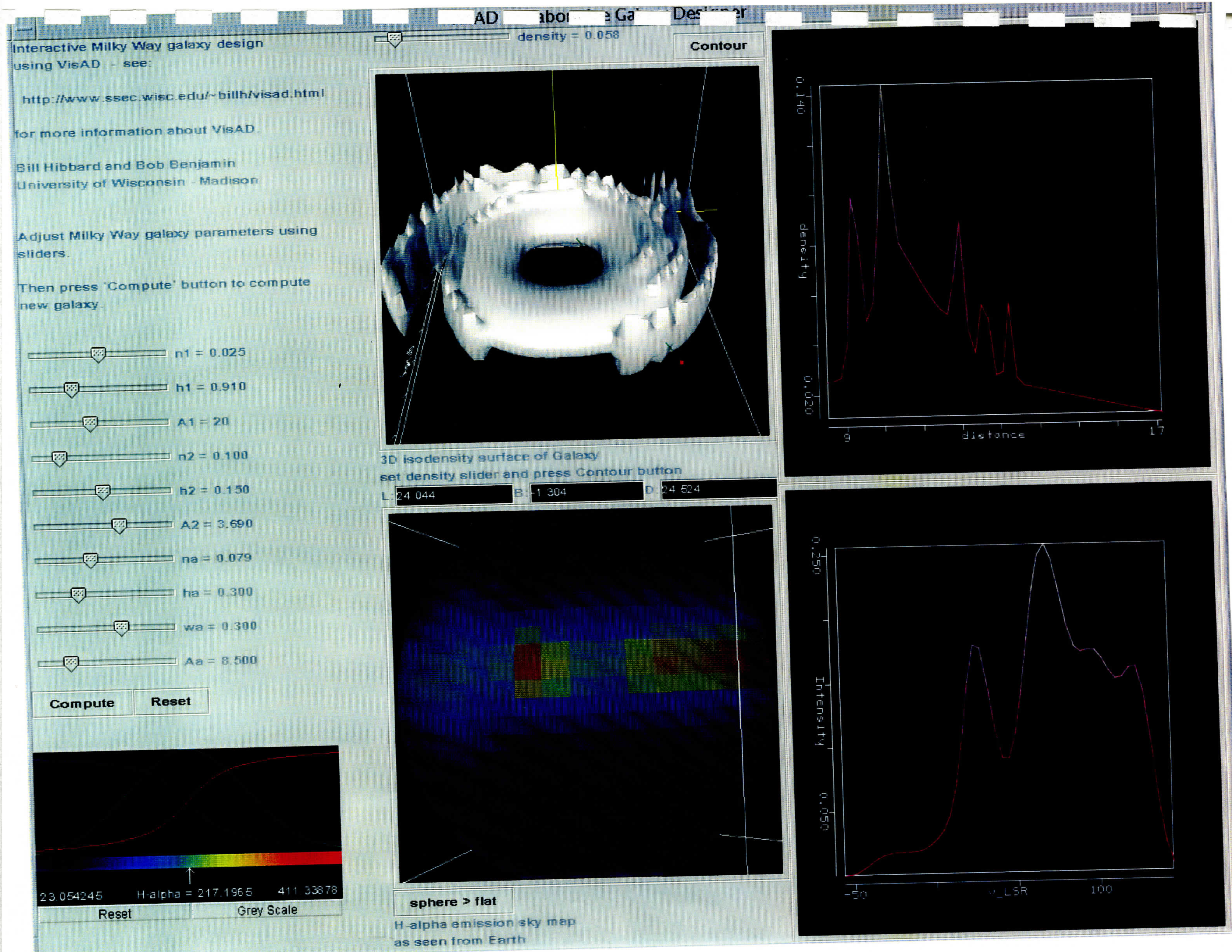
VisAD defines a general display model. This has been implemented for Java2D and Java3D. Data objects are linked to display objects, so that whenever data values change their depictions are updated. One novel feature of this display model is that, when allowed by applications, users can modify values of data objects by redrawing their depictions. This is valuable for creating user interface controls embedded in data displays. Java3D provides a link to immersive virtual reality. We demonstrated this at the NCSA Alliance 98 Conference, with collaboration between an ImmersaDesk and a desktop workstation. Note that embedded user interface controls are essential in immersive virtual reality.

Working with Robert Benjamin, a scientist in Don Cox's astrophysical theory group of the University of Wisconsin Physics Department, we have developed and are continuing to develop a "Collaborative Galaxy Designer" based on VisAD. This application enables scientists to remotely collaborate on experiments to fit a model of the spatial distribution of warm (10,000 K) ionized gas in the Milky Way to the observed sky distribution of ionized gas currently being obtained by Prof. Ron Reynolds and Dr. Matt Haffner using the Wisconsin H-alpha Mapper (WHAM). The model of the spatial distribution is based on an Astrophysical Journal article by Taylor & Cordes (1993, ApJ 411, 674) using the dispersion measure of pulsars of known distances. Users adjust model parameters and see model output depicted both as a 3D isodensity surface, and also as an all-sky projection of the expected H-alpha emission integrated out a distance of 6 kpc. Users can toggle between a flat sky (Hammer-Aitoff) projection and a projection onto a rotating sphere, as shown in the lower center window the attached figure.

The Collaborative Galaxy Designer also gives users a custom cursor embedded in the 3D isodensity surface display, representing a point in 3D space near the Milky Way and a line connecting it with the Sun. As users drag this point with the mouse, they see graphs of modeled density versus distance and modeled emission versus velocity along the line connecting it with the Sun. The graph of emission versus velocity is appropriate for comparison with measurements from WHAM. The Collaborative Galaxy Designer can be run in server mode, so that collaborators at other machines can see the same Milky Way galaxy design simultaneously. Dr. Benjamin gave a demonstration of the Collaborative Galaxy Designer at the September 1999 *Green Bank Workshop on Warm Ionized Gas in Galaxies,* which was reported on by Minter et al. (2000, PASP, Vol. 112, No. 769, 424).

On-line documentation for VisAD includes the VisAD Class Library Developers Guide (approximately 140 pages), full source code; JavaDoc generated from source code, approximately 100 example applications, and an archive of questions and answers on the VisAD mailing list. The system and its documentation are all freely available at:

http://www.ssec.wisc.edu/~billh/visad.html



Interactive Milky Way galaxy design
using VisAD - see:
http://www.ssec.wisc.edu/~billh/visad.html
for more information about VisAD.
Bill Hibbard and Bob Benjamin
University of Wisconsin - Madison
Adjust Milky Way galaxy parameters using sliders.
Then press 'Compute' button to compute new galaxy.
n1 = 0.025
h1 = 0.910
A1 = 20
n2 = 0.100
h2 = 0.150
A2 = 3.690
na = 0.079
ha = 0.300
wa = 0.300
Aa = 8.500
Compute
Reset
23.054245
H-alpha = 217.1965
411.33878
Reset
Grey Scale
density = 0.058
Contour
3D isodensity surface of Galaxy
set density slider and press Contour button
L: 24.044
B: -1.304
D: 24.524
sphere > flat
H-alpha emission sky map
as seen from Earth
0.140
density
0.020
9
distance
17
0.250
Intensity
0.050
-50
V_LSR
100